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## Lessons learnt in building VO resources: binding together several VO standards into an operational service

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**Abstract.** The International Virtual Observatory Alliance (IVOA) developed numerous interoperability standards during the last several years. Most of them are quite simple to implement from the technical point of view and even contain “SIMPLE” in the title. Does it mean that it is also simple to build a working VO resource using those standards? Yes and no. “Yes” because the standards are indeed simple, and “no” because usually one needs to implement a lot more than it was thought in the beginning of the project so the time management of the team becomes difficult. In our presentation we will start with a basic case of a simple spectral data collection. Then we will describe several examples of small” technologically advanced VO resources built in CDS and VO-Paris and will show that many standards are hidden from managers’ eyes at the initial stage of the project development. The projects will be: (1) the GalMer database providing access to the results of numerical simulations of galaxy interactions; (2) the full spectrum fitting service that allows one to extract internal kinematics and stellar populations from spectra of galaxies available in the VO. We conclude that: (a) with the existing set of IVOA standards one can already build very advanced VO-enabled archives and tools useful for scientists; (b) managers have to be very careful when estimating the project development timelines for VO-enabled resources.

### 1. Introduction

On the side of IVOA we now have a comprehensive set of standards(Arviset et al. 2011) including: data formats (VOTable, Ochsenbein et al. 2011), VO resource description (Resource Metadata), data models for 1D spectra (Spectrum Data Model) and simulations (SimDM/SimDB) and much more complex and general Characterisation Data Model (Louys et al. 2011b), Astronomical Data Query Language, protocols to access tabular data (TAP, Dowler et al. 2011), images (SIAP), and spectra (SSAP, Tody et al. 2011), a Simple Application Messaging Protocol (Taylor et al. 2011) that allows different VO tools and services to talk to each other, authorisation and authentication

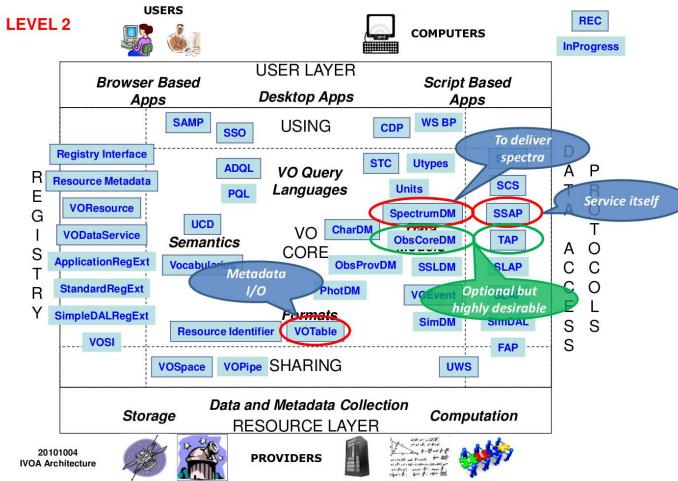


Figure 1. IVOA standards required (red) and recommended (green) to implement a simple spectral data collection access by a data centre.

mechanisms, and others. Some other standards are still at different phases of development. Now it became possible to handle even very complex astronomical datasets in the Virtual Observatory, such as 3D spectroscopy (Chilingarian et al. 2006, 2008) and results of N-body simulations. Some of the standards even carry the adjective “simple” in their titles.

Is it really simple and fast to implement operational VO services using these standards? Unfortunately, many (mostly technical) aspects are often hidden from the view. And the implementation of these details may take significant amount of time.

## 2. Examples

### 2.1. Spectral Data Collection

The simplest case is a collection of 1-dimensional spectral data. One may think that such a service requires the implementation only of the SSAP. However, to make I/O of the spectral data one needs to implement the Spectrum Data Model and its serializations including VOTable. At present, the implementation of the TAP access using the Observation DM Core Components (Louys et al. 2011a) is highly desirable. All standards that one needs to implement in order to build an operational VO spectrum data access service are shown in Fig. 1 on the VO Infrastructure Diagram.

### 2.2. The GalMer Database

The first “technologically advanced” project that we describe here is the GalMer database. The GalMer database is a part of the Horizon project, providing access to a library of TreeSPH simulations of galaxy interactions Chilingarian et al. (2010). We have developed a set of value-added tools related to data visualization and post-processing with available VO-interfaces, including the spectrophotometric modelling of galaxy proper-

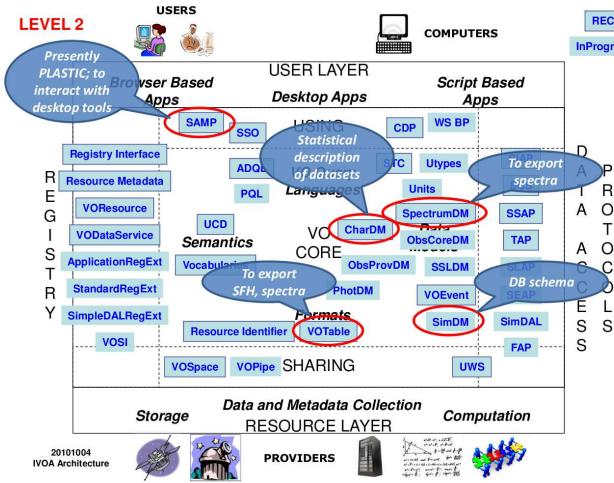


Figure 2. IVOA standards required to implement the GalMer database and services.

ties, making GalMer the most advanced resource providing online access to the results of numerical simulations. These tools allow direct comparison of simulations with imaging and spectroscopic observations (see e.g. Chilingarian et al. 2009).

The database schema of GalMer is based on the SimDM data model (see Fig. 2). We use Characterisation DM in order to provide the advanced statistical description of datasets. Spectrum Data Model is used for the “virtual telescope” service, i.e. the on-the-fly spectrophotometric modelling. Spectral and imaging data are displayed using an integration of a browser with desktop VO tools, we use PLASTIC, a SAMP precursor.

### 2.3. Full Spectrum Fitting of 1D Spectra of Galaxies

The last example is an operational VO service providing access to the full spectrum fitting service implementing the “Penalized Pixel Fitting” technique (Cappellari & Emsellem 2004). This tool allows one to fit a set of stellar population models against an observed 1D absorption line spectrum of a galaxy and determine its internal kinematics (radial velocity, velocity dispersion and higher order moment of the line-of-sight velocity distribution, see van der Marel & Franx 1993). We are presently working on the implementation of the NBursts pixel fitting algorithm (Chilingarian et al. 2007b,a) that also returns stellar population parameters in the same minimization loop.

We implemented our service for the Sloan Digital Sky Survey (Abazajian et al. 2009) data (see Fig. 3) as a Universal Worker Service (Harrison & Rixon 2011) that executes a compiled binary on a server. In addition to UWS, we had to implement SSAP over SDSS data, and SAMP to interact with Aladin and VOSpec.

## 3. Summary

Our conclusion is that in many cases with the existing set of IVOA standards one can already build very advanced VO-enabled archives and tools useful for scientists. How-

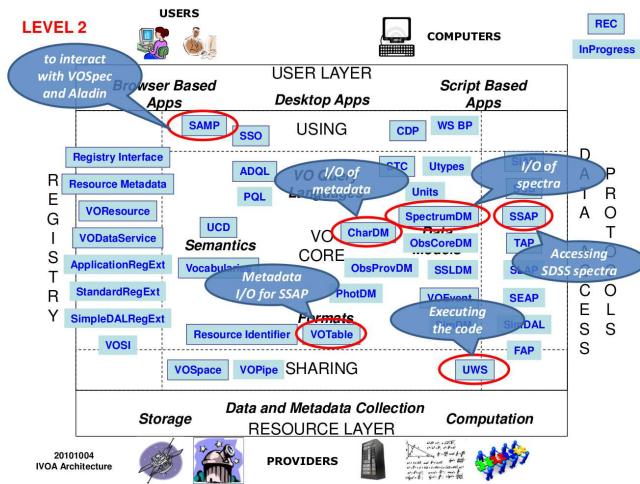


Figure 3. IVOA standards required to implement the full spectrum fitting service.

ever, project managers have to be very careful when estimating the project development timelines for VO-enabled resources as a significant manpower overhead may be needed.

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